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TECHNICAL BULLETIN No.17

Fodder establishment, management and utilization techniques for the smallholder

ESGPIP

ETHIOPIA SHEEP AND GOAT PRODUCTIVITY IMPROVEMENT PROGRAM

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Foreword

This Technical Bulletin titled "*Fodder establishment, management and utilization techniques for the smallholder*" is produced by the Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP). The ESGPIP is a USAID funded Project with the objective of improving the productivity of Ethiopia's sheep and goats.

The Technical Bulletin is intended to serve as an extension aid for Kebele Development Agents (KDA's) to promote production and utilization of improved fodder crops. It is believed that the information contained in this technical bulletin will be transferred to sheep and goat producers and help improve availability of quality feed that would sustain productivity of sheep and goats and income generated thereof. It will also be useful for other users engaged in the production of other types of ruminants.

At this juncture, I would like to thank all those involved in the preparation and review of this technical bulletin.

Desta Hamito (Prof.),
Chief of Party,
ESGPIP
September, 2008

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FODDER ESTABLISHMENT, MANAGEMENT AND UTILIZATION TECHNIQUES FOR THE SMALLHOLDER

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1. Introduction

Sheep and goats constitute a vital component of the Ethiopian agricultural sector. They are well integrated with the farming systems found in the highlands and provide a good share of the means of subsistence for the nomadic pastoralists in the lowlands. They are the source of many social and economic values such as food, cash income including foreign export, security and investment in both the highlands and lowland/pastoral systems. Typical of the livestock sector as a whole, the sheep and goat resource of the country is characterized by low productivity levels. Average yields per animal slaughtered is 10 kg of mutton or goat meat. Thus, despite their contribution to the household food security and the national economy at large, productivity remains very low due to various constraints including: inadequate feed and nutrition, low level of veterinary care, prevalence of diseases and parasites, low r genetic potential, poor technology transfer, land tenure, and recurrent drought. The former constraint, i.e., poor feed availability is the outstanding constraint at present and thus the subject of this bulletin.

Sheep and goats are usually reared in mixed herds with other kinds of livestock. This is typical of smallholder agriculture systems, especially in the highlands. These systems are characterized by low inputs; production based on human and animal power; small landholding, and mixed crop/livestock modes of production. Therefore, in designing any productivity improvement intervention, one should consider this scenario and select technologies that fit the capacity of the smallholder farmer. Fodder production technologies meant for the smallholder must be seen in this context. Conventional pastures, as practiced in the developed world, have no place under the smallholder conditions now or in the near future. Fortunately, there are technology options that can offer new hopes in alleviating animal feed crisis prevailing in the country. These technologies must be vigorously introduced into the farming community. There are numerous technology options that can be introduced to farming communities considering each specific situation.

2. Basic technical procedures of fodder establishment

2.1. Seedbed preparation

Grass seeds are very small in size and thus one has to prepare a seedbed which is favorable for seed germination, seedling emergence, and growth.

Procedures

- ***Clearing*** **-** Clear trees, bushes and coarse herbs prior to ploughing using slashers ('*gejera'*) or ring barking (for trees) – removing surface bark from a strip 10 cm wide around the trunk (See Figure 1).

- ***Ploughing***- first deep ploughing, then shallow ploughing to a fine, firm, even, and level seedbed.

- ***Rolling***- done after sowing to consolidate the soil and provide better soil/ seed contact.

Figure 1. Tree clearing by ring barking.

2.2. Fertilising and manure application

If the soil is depleted of nutrients by continual cropping or soil erosion basal applications of the macronutrients, especially nitrogen (100-150 kg/ha urea) and phosphorus (50 kg/ha triple superphosphate), are helpful for successful establishment on most soil types of Ethiopia. Where available farm yard manure is a less expensive option for the smallholder and can be applied at the rate of 5-10 tons/ha. If the pasture to be established contains a good proportion of adapted and readily nodulating legumes, the nitrogen application may be ignored or reduced to a starter dose (10-25 kg urea/ha) in anticipation of atmospheric nitrogen fixation after some weeks by the legume component.

2.3. Planting

2.3.1 Planting by seed

2.3.1.1. Seed considerations

• ***True variety***: The seed must be true to the variety one is intending to plant. To assure this it is advisable to obtain seed from a reputable source.

• ***Seed quality***: Quality is a function of purity (free from weed seeds, broken seed, chaff, soil, etc) and viability (ability to readily germinate). One has to use high quality seed to establish the pasture. Commercial seeds are usually accompanied by 'passport data' that show recent seed analysis statement for the seed to be sown. Presence of weed seed, especially from exotic sources, should not be tolerated so as not to introduce new, potentially serious weeds into the pastureland.

• ***Seed dormancy:*** Seed dormancy or inability to germinate is a natural protective phenomenon which prevents premature germination of seed to ensure long-term survival of species. Seed dormancy could be due to either an inactive embryo that fails to germinate (e*mbryo dormancy*) or a hard seed coat restricting entry of water and air (d*ormancy due to seed coat characteristics*). The former type dormancy can be solved by storing freshly harvested seed for some period (*after ripening period*) depending upon the species history. Germination failure due to hard seed coat could be overcome by a number of techniques.

•. ***Mechanical scarification***: The seed coat is abraded by passing over abrasive surfaces.

- rubbing with sand paper if sowing small quantities for seed (Figure 2).
- for large quantities, a drum scarifier can be used (seed-mixer drums the inside surface lined with abrasive material) (Figure 3).

• ***Acid treatment*****:** immersion of seed in concentrated acid such as sulfuric acid, the duration of treatment depending on species.

• ***Hot water treatment:*** immersion of seed in water, the temperature and duration of treatment depending on species (Figure 4).

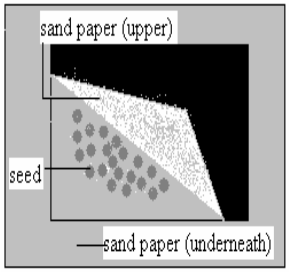


Figure 2. Seed scarification by rubbing the seed in between two pieces of sandpaper.

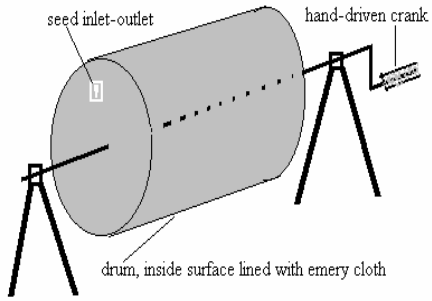


Figure 3. Scarifying seed by using a drum scarifier.

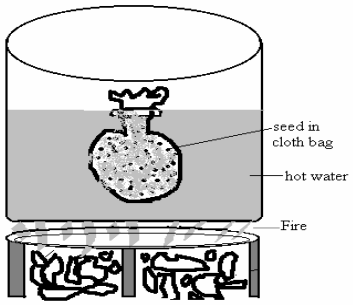
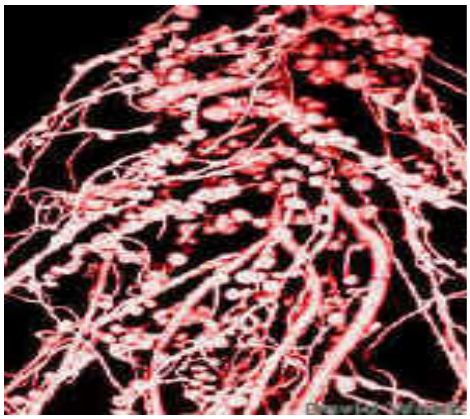
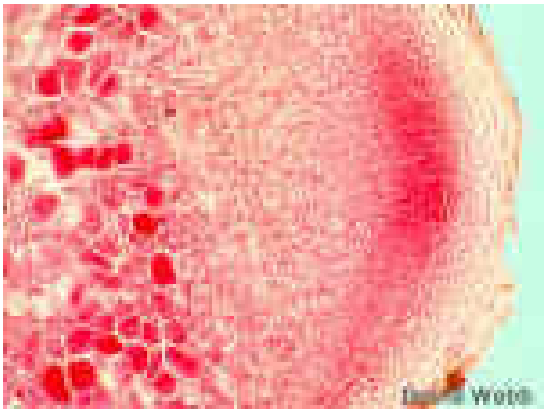


Figure 4. Scarifying seed by immersing in hot water

• Inoculation

Inoculation applies to legumes. Pasture legumes require the presence in the soil of a strain of nitrogen-fixing bacteria (*Rhizobium*) suited to an effective symbiosis. Some legumes are very specific in their rhizobium demands. Inoculation is recommended particularly when introducing new species into new areas to ensure that the species are nodulated by the most effective and efficient *Rhizobium* bacteria strains. The culture is most commonly in the form of a peat culture (a black powder), but may also be a slope culture on agar gel, or rarely a freeze-dried culture.

Most native legume species do not require inoculation since they can be infected by bacteria strains living in the soil. A working, effective nodule should be pink inside but ineffective nodules are either white or green (Figure 5)

5a. A well-nodulated legume root 5b. Pink internal pigment

Figure 5. Profusely nodulating legume with internal pink pigment indicating efficient nitrogen fixation

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Inoculation procedure:

- Make a slurry of the inoculant in water and mix with the seeds thoroughly to make all seeds wet.
- Add a small quantity of sugar solution (10%) to the slurry to make it sticky. For Inoculating 1 kg of seed, one-half teacup full of sugar is sufficient.
- Inoculation and drying should be done in the shade.
- Inoculated seeds should be sown within 24 hours after inoculation.

• Seeding rate

Seeding rate depends primarily on the viability and purity of the seed. Furthermore, seeding rate depends on seed size, pure stand or mixture, amount of rainfall and soil fertility. As a general guideline, for row planting, sow grasses at 6-8 kg/ha, legumes at 3-4 kg/ha, and fodder shrubs 10-15 kg/ha. For broadcasting, sow at double the rate recommended for row planting.

2.3.1.2. Sowing practice

Timing. The best time is immediately before the season of the most reliable rainfall and when temperature is favorable. Sow perennial species at the onset of the longest wet season when the soil has received sufficient moisture to support germination and establishment.

Spacing: Generally, spacing between two rows should not exceed 25-45 cm and about 5-15 cm between two plants in the row.

Depth: Generally the smaller the seed the shallower the depth of planting. Usually, grasses are sown at the depth of 1-1.5 cm depth; while the medium sized legumes seeds are sown at 2.5cm depth.

Method of sowing:

- Two ways:
  - row sowing and
  - broadcasting

- Row sowing has the following advantages over broadcasting:

  - Low seeding rate is required (seed economy).
  - Better establishment in case of poor weather conditions.
  - Easy weeding and fertilizer application
  - Better exposure of plants to sunlight

When planting in rows manually, mark the rows with a stick or a row marker having adjustable spikes. Sow the seeds in the row and cover with a thin layer of soil and press down by feet (men or animals) to ensure good soil to seed contact.

When row planting is not possible, the sowing rate should be doubled to compensate for poor seedling survival. In covering surface sown seeds, driving animals back and forth, or dragging a spiny tree branch devoid of leaves (Figure 6), has been observed to give good results.

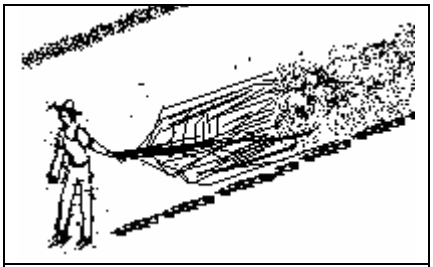

Figure 6. Seed covering by dragging a leafless tree branch.

3.2. Planting by vegetative parts

Vegetative propagation is necessary for establishing sterile plants, erratic-seeders and for plants giving seed of low genetic stability (hybrid varieties; segregating populations).

Methods

- ***Tuft splits***: Tuft splits may be dug out by hand and taken to the establishment area and planted in furrows.

- ***Stem cuttings***: Ample soil moisture is necessary. Mature stems bearing three nodes are cut and planted in furrows or surface broadcast and covered with soil; two nodes buried and one left above ground. The spacing is 0.7 X 0.3 m inter-row and for runner grasses 2 X 2m spacing in the row is recommended if weed control is adequate and early season grazing avoided (Figure 7).

2.3.2. Planting by seedlings

For browse trees and shrubs it is advisable to raise seedlings some two months ahead of the rainy season using plastic bags in a nursery house. The procedures are:

- Prepare a mixture of fine sand, forest soil and farmyard manure.
- Mix well and moisten by sprinkling with water and filling the plastic pots.
- Arrange the pots under a nursery shed and plant viable seeds (two seeds per hole if seed is not limiting)
- Supply adequate water every day. Monitor germination and remove any weeds.
- Thin seedlings to one strong plant per pot.
- At the start of the rainy season dig out planting holes in the target field a week or so before planting to allow adequate water infiltration.
- Preferably on a cloudy day, plant the seedlings in the prepared holes and return the topsoil followed by the subsoil and press firmly (Figure 8).

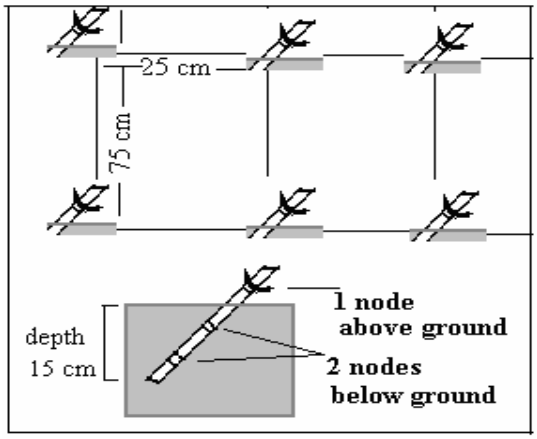

Figure 7. Vegetative (stem cutting) propagation.

Figure 8. Transplanting a seedling raised in plastic tube

2.4. Management after sowing

2.4.1. Weed management

The newly established pasture has to be kept free of coarse weeds, especially broadleaf weeds, which are usually a threat to sward consolidation. Remove weeds by hand or by spraying herbicides before weeds flower. This reduces competition when grasses are weak while minimizing further perpetuation of weeds by seed.

2.4.2. Fertility management

Fertilizers should be applied according to the fertility status of the soil. To determine what nutrients are needed:

- Observe characteristic symptoms, e.g., leaf yellowing is likely a nitrogen deficiency.
- Undertake soil and plant tissue analysis.
- Know the characteristics of the plant, e.g., tall and rank-growing grasses such as elephant grass and *Panicum* species are heavy feeders and require more frequent fertilizer applications than thinner and shorter stature grasses.

Generally, legumes have a high requirement for P, S, and Mo; grasses have a high requirement for N, P, and K. Levels of nutrients used will depend on soil type, species used, level of production required, and production system (cut-and-carry systems require greater maintenance inputs than grazing systems). Typical levels of nutrients required for annual maintenance are 50–300 kg/ha N; 10–20 kg/ha P; 25–50 kg/ha K; 30 kg/ha S; and 100–200 kg/ha Mo. Nitrogen is often applied at each grazing or cutting. Phosphorus should also be applied especially if the legume component loses vigor due to grass dominance. Manipulating the ratio of application of nitrogen and phosphorus is a useful management technique to maintain a desirable balance between the grass and legume components.

2.4.3. Grazing/defoliation management

- The newly established pasture can be utilized within 2–8 months after sowing. This is only possible if proper grazing or cutting is ensured.
- Rotational or periodic grazing is usually recommended. However, some species may not respond to rotational grazing and this situation has to be treated cautiously. As a precaution, stocking rate should be greatly reduced or grazing totally stopped when no more than 50% of the weight of herbage has been consumed.
- If sown pastures are well-utilized and maintained with fertilizers, they will continue to provide high herbage yield for up to about five years and start to decline thereafter.

3. Fodder technology options that fit the smallholder

3.1. Criteria for selecting technologies for the smallholder

- As much as possible, the technology should not compete with or displace food/cash crop unless the monetary value is on par with the opportunity cost of the land.
- The fodder crop must be high yielding and nutritious to be used as supplementary feed to basal feeds based on crop residue and native hay.
- It must be responsive to intensive management such as fertilizing/manure application and irrigation.
- It must be tolerant to frequent clipping.

3.2. Backyard fodder crops

3.2.1. The essence, opportunities and challenges

Backyard forage/fodder crops include highly productive species grown around a farmer's homestead under intensive management conditions. The objective is to produce high quality fodder as supplementary feed for highly productive dairy cows and young animals. One form of backyard fodder is 'live fencing' whereby woody plants are planted in and around housing compounds and farm yards. Live fences can be permanent or semi-permanent structures and different species of plants are suited to this purpose. Highly productive fodder species recommended for this system include:

- Fodder beet (*Beta vulgaris*)
- Alfalfa (Lucerne) (*Medicago sativa*)
- Elephant grass (*Pennisetum purpureum*)
- Tree Lucerne (*Chaemacytisus palmensis*)
- *Sesbania sesban*
- *Leucana leucocephala*
- *Leucana pallida*

These promising fodder species are described in section 5.

3.3. Fodder banks

3.3.1. The essence, opportunities and challenges

Fodder banks are small, densely sown stands of either herbaceous or tree legumes (sometimes mixed stands) providing high quality fodder for dry season feeding supplementing native forage or crop residues. The idea of fodder banks emerged with the aim of replenishing arable lands that have lost their fertility due to continuous cropping. Thus, a fallow land is sown to leguminous perennial forages or self-seeding perennials so as to rebuild the nitrogen content of the soil through biological nitrogen fixation, and at the same time, for production of high quality dry season fodder. The system is like a forage/crop rotation except that the forage phase may last for three or more years until the desired fertility level of the soil is attained. Nowadays, fodder bank systems have been extended to the utilize all available open lands around a farmer's homestead including crop borders, sloped or stony pieces of land, and bottomlands that are not suited for normal crop production. On such lands, intensive fodder crops are grown basically as a dry season feed reserve- 'green or conserved feed banking'. Species suited for fodder banking are highly productive and nutritious since the basic idea behind this approach is to use the quality fodder as strategic supplementary feeding to fibrous roughages over the dry season. Forage species that have such characteristics are more or less the same as those suited for backyard fodder systems and include herbaceous and woody legumes, root fodder crops and some grass species that are responsive to intensive management. Promising fodder species identified as fit for fodder banks are described in section 5.

3.4. Feeding and conservation of fodder crops

Green chop: (fresh leaves and branches) fed as cut-and-carry fodder to housed stock is often practiced by commercial dairy farms and feedlot cattle finishers. When the green chop feeding operation is aimed to collect animal excreta in a confined space and return it to the land to build soil fertility, it is called '*soilage*'. In feeding green chop using legume fodder one must be aware of bloat (tympania), a serious fatal incidence due to lush forage-induced restriction of belching out gases from the rumen. Bloat occurrence can be minimized by wilting the fodder for some hours before feeding. Mixing the fresh legume fodder with dry fibrous feedstuff is also another feeding strategy to lower bloat incidence.

Advantages of cut-and-carry systems

- High recovery of plant material as it is not lost by trampling and contamination.
- Little selectivity because the system allows for rationing of animal intake.
- Feeding can be arranged at a convenient site.
- The excreta can be utilised as farm yard manure and applied where it is most required.

Limitations of cut-and-carry system

- Continuous removal of plant material can lead to a deficiency of soil nutrients particularly potash.
- High labor requirement for cutting, chopping and transporting.

Hay: Hay is feed produced by dehydrating green forage to a moisture content of 15 % or less. Hay is the best way of conserving any excess fodder that might be produced during the wet season. It is important to bridge the gap in feed supply that occurs during dry seasons, droughts and when grazing land is scarce during the cropping season. Providing stored hay during these times is essential in improving sheep and goat production.

The aim of conserving fodder, be it as hay or silage, is to harvest the crop at its maximum nutrient content, minimize nutrient losses while at the same time maintaining its acceptability to the animal. The time of harvest in the context of intensive fodder crops must be early so as to attain the higher protein content badly required to supplement fibrous basal diets. Therefore, time of cutting of hayed fodder must be early in the flowering stage.

Curing of hay: The grass should be dried quickly and not unduly exposed to the sun. Rain can cause leaf losses and leaching of nutrients. Tropical pasture grasses generally take 50-55 hours of drying in good weather and 70-75 hours in humid weather.

Hay making steps for the smallholder:

- Harvest the plant at the optimum stage of maturity which will provide a maximal yield of nutrients per unit of land. Most forage should be mowed soon after reaching an early bloom stage of maturity.

- Start harvesting after the dew has evaporated from the green material late in the morning.

• Cut and place the material into small heaps about 20-30 cm high and turn the heap frequently in the sun to encourage quick drying. Raking (turning) should be completed before it is completely dry to avoid excessive shattering of leaves and overexposure to the sun. It is better if raking is done when the dew is on, especially when high leaf shattering is expected. If the weather is humid or rainy, place the cut material off the ground using a home made-tripod consisting of three poles (Figure. 9) to facilitate drying.

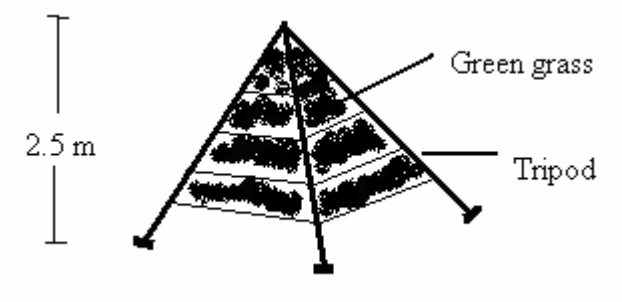

Figure. 9. Hay making tripod

Leaf hay: Woody legume species like Sesbania and Leucaena produce abundant leaf during the wet season which must be conserved in the form of leaf hay. Leaf hay is easy to feed, transport and store (See Figure 11).

How to make leaf hay

Fresh branches are harvested at an early flowering stage and allowed to dry in the sun on a plastic sheet or concrete floor. The leaves are separated from the stem by beating the dried material on the floor. The leaves are then collected and stored in sacks or in any container until used (See Figure 11).

5. Selected fodder crops for backyard / fodder bank systems

5.1. Alfalfa (Lucerne) (*Medicago sativa*)

- **Cultivation**: When grown as an intensive fodder crop (backyard/fodder bank), it is established near animal barns where there is a better possibility of supplying irrigation and farmyard manure, and where it is easily transported since the usual feeding system is as cut-and-carry green fodder. It is best established on a well-prepared fine, firm seedbed. As a pure stand fodder crop, the seeding rate is 10 – 20 kg/ha under irrigation and 6 – 12 kg/ha under rain-fed conditions (the lower rate for dry land environments).

- **Suitable agro-ecology and growth requirement**: Alfalfa adapts to a wide range of environments and performs well at elevations from 1,000 to 2,500 m. It prefers deep, well drained loam soils. Poor drainage promotes root and crown diseases, inhibits nitrogen

fixation, and reduces frost survival. Alfalfa tends to be sensitive to soil acidity. A soil pH between 6.5 and 8.0 is satisfactory for optimum forage production. It is relatively drought tolerant.

- **Fertilizer requirement**: Basal application of 40 kg TSP/ha

- **Expected yield**: Yields of 7-17 tons/ha dry matter (under irrigation) are possible

- **Usage:** The optimum growth stages for harvest are mid- to late bloom, because higher yields can be obtained and quality is still acceptable. Alfalfa is fed as a supplemental, protein-rich fodder to dairy cows and calves, mostly as green fodder, sometimes conserved as hay. Each ton of alfalfa hay contains about 22.7 kg of nitrogen, 4.54 kg of phosphorus and 27.24 kg of potassium. Usually green chop is fed to dairy cows at milking time every day. Where irrigation is available, multiple harvests every 3-4 weeks are possible (e.g., at Debre Zeit) (Figure 10).

- **Selected varieties/cultivars:** Hunter River, Hairy Peruvian

- **Seed source**: Commercial cultivars available. Various seed companies in Italy, Spain, Portugal, France and UK can be contacted. For local supply, limited quantity of foundation seed could be found from the Debre Zeit Agricultural Research Center (DZARC) or other Research centers.

Figure 10. Alfalfa (Lucerne) (*Medicago sativa*) in early bloom ready for harvest

5.2. Macrantha (*Sesbania macrantha*)

Macrantha is an annual or short-lived perennial (up to three years) Sesbania, newly introduced for fodder development.

- **Cultivation:** Grown as a supplemental fodder crop around animal barns for eas of cut and carry feeding. Established from seed on lightly ploughed land. Plant spacing may be varied depending upon soil fertility and availability of irrigation.

- **Suitable agro-ecology and growth requirement**: Adapted to medium to high altitude highlands, 1,500-2,400 meters above sea level, mean annual rainfall 800 mm and above.

- **Seed rate:** Direct seeded in rows 1 m apart, 0.5 m between plants

- **Fertilizer requirement:** 20-30 kg TSP/ha, basal application.

- **Expected yield:** When grown as an annual fodder crop up to 9 t/ha total dry matter (3 t/ha dry leaf plus 6 t/ha wood, which is good for light cooking) can be expected in a three and one-half month growth period.

- **Utilization:** Fed as green fodder or as cured leaf hay as a high protein supplement to crop residue or poor quality hay. The cured hay can be stored in sacs for long period until use (Figure 11), while the wood portion can be used as fire wood for light cooking.

- **Selected varieties/cultivars:** Annual forms are more productive under rain-fed conditions whereas short-lived perennials more suited for irrigated conditions.

- **Seed source**: No commercial cultivars developed yet. Limited quantity of foundation seed could be found from DZARC.

Figure 11. Leaf hay of *Sesbania macrantha* is easy to store, transport and feed.

5.3. Sesbania (*Sesbania sesban*)

Sesbania is a relatively short-lived (6–7 years) shrub or small tree up to 6 m high (Figures 12 and 13).

- **Suitable agro-ecology and growth requirement**: A wide range of adaptation, 200–2,400 m.a.s.l. Grows best under moisture-stress free conditions, versatile in its requirement.
- ***Cultivation:***
    - Propagation: By seed; seed must be scarified by immersing the seed in concentrated sulphuric acid for 30 minutes; also mechanically by using drum scarifiers. Plant seedlings

at the onset of first rains. Spacing: variable according to uses:

- Continuous hedges: 50 seeds/m or 2–3 seeds/hole at 0.5 spacing.
- Alley cropping: up to 4 m or more between alleys.

- ***Herbage yield potential:*** Second only to Leucaena as a fodder-producing tree.
- ***Utilization:*** Cut at 0.5–1.0 m height at 6–8 week intervals; use as supplement (20–30%) with crop residues. There is no toxicity if higher levels are fed.
- **Seed source**: No commercial cultivars developed yet. Limited quantity of foundation seed could be found from DZARC.

Figure 12. Leafy branch of Sesbania (*Sesbania sesban)*

Figure 13. Cattle relish the fresh leaves of Sesbania grown as backyard fodder along the fence.

5.4. Leucaena (*Leucaena leucocephala*)

Leucaena is a long-lived shrub or tree up to 20 m high (Figure 14). It is a vigorous plant of high yield and high-quality protein; leaves and thin twigs well-accepted by livestock.

- ***Suitable agro-ecology and growth requirement*:*:*** Performs best under warm climate at low altitudes less than 2,000 m, sensitive to frost, drought-tolerant, can grow at 400 mm annual mean rainfall.
  - ♦ Altitude range: less than 2,000 m.a.s.l.
  - ♦ Soil requirement: Well-drained soils; not tolerant to acid soils; favors neutral-to-alkaline soils (pH 6.0).
- ***Cultivation:*** Light cultivation for direct sowing; dug holes for transplanting.
  - ♦ Propagation: Propagation by seed sown at 4–7 kg/ha, but different rate or spacing can be used depending on utilization; sowing depth: 2–3 cm. Spacing when sown 2–2.5 m between rows to up to 4.0 m between rows/alleys. Usually planted by seedlings.
  - ♦ Treatments: Seed treatment necessary. Hot-water treatment 60–80^{o}C; H_2SO_4 for 10 minutes.
  - ♦ Inoculation with appropriate rhizobium strain is helpful.
  - ♦ Fertilizer requirement: On acid soils, liming may be necessary.
  - ♦ Companion species: May be planted to pasture grasses in inter-row spaces.

- ***Productivity:*** Considered the best fodder tree in the world. Multipurpose (for fodder, fuel, pulp, immature shoots and seeds for human consumption, shade and hedge). Yields of 50 t/ha (cut at ground level) and 40 t/ha (at 75cm) have been reported.
- **Utilization**: Cut at 80–100 cm height every 6–8 weeks; use as a supplementary ration 25–30%; beyond this level animals develop enlarged thyroid gland or goiters because of mimosine (an alkaloid) preventing animals from using iodine efficiently. Feeding Leucaena needs an adaptation period of 10-15 days because of palatability problems. It is fed as the first feed in the morning before crop residue is offered. For best results split-feeding of Leucaena is recommended. Half the daily allowance is given in the morning and the remaining half in the after noon.
- **Seed source**: Contact DZARC and other EIAR centers

5.5. Pigeon pea (*Cajanus cajan*)

Pigeon pea is an erect shrub or short-lived perennial herb (Figure 15).

Suitable agro-ecology and growth requirement: adapted to arid and semi-arid environments, drought-resistant but susceptible to frost; can grow at 500–800 m annual rainfall; tolerates acid soils.

Cultivation: Established from seed sown at the rate of 4–6 kg/ ha or 1–20 kg/ha broadcast. Spacing: about 1 m apart between rows. Seed scarification and inoculation are not necessary.

Fertilizer requirement: Responds favourably to P fertilizer but negatively to N.

Productivity*:* Up to 12 t/ha DM

Expected yield: Up to 12 t/ha DM

Utilization*:* Dual-purpose crop for food and forage. For forage: cut when the first pods begin to ripen at 50–25 cm height.

Selected varieties / cultivars: commercial varieties available

Seed source: Contact local research centers, IITA (Nigeria), ICARDA (Allepo, Syria)

Figure 14. Leucaena (*Leucaena leucocephala)*

Figure 15. Dual purpose pigeon pea crop in farmer's backyard

5.6. Tree Lucerne (Tagasaste) (*Chamaecytisus prolifer*)

Tree Lucerne is a shrub or small tree (Figure 16). Useful as a multipurpose fodder tree for cut-and-carry fodder, ornamental, windbreak, bee forage, fuel wood and biogas. It can be planted as a hedge and also has potential for alley-cropping systems.

- ***Suitable agro-ecology and growth requirement:*** Wide range of adaptation from low to 3,200 m.a.s.l. altitude, the only browse legume adapted to higher altitude highlands of Ethiopia. Tolerates infertile and acid soils and droughts once established. Needs good drainage. Grows well on light, well-drained sandy soils on slopes and hillsides. It has a wide range of adaptability to soil pH (4.0–8.5). Tagasaste grows well up to altitudes approaching 3,000 m in the tropics and is one of the few fodder trees that can withstand frost as low as -9ºC in the tropical highlands.

Cultivation:

- ♦ Propagation is by seed sown directly or by transplanting. Spacing 30–50 cm between plants.
- ♦ Seed treatment necessary. Dip in boiling water for 5–10 minutes.
- ♦ Inoculate if possible.

- ***Utilization:*** Establishment is slow. Commence cutting in the second year. Cut at 1 m height every 6–8 weeks. Use as a supplement to crop residues.
- ***Reproduction:*** Seed yield up to 0.5 kg/tree.

Figure 16. Tree lucerne (tagasaste) (*Chamaecytisus prolifer).*

Figure 17. Elephant grass (Pennisetum purpureum)

5.7. Elephant grass (Napier grass) (*Pennisetum purpureum)*

Elephant grass is a robust perennial with a vigorous root system, sometimes stoloniferous with a creeping rhizome, culms 180–360 cm high (Figure 17). It is valued for its high DM yield; deep roots can forage widely for moisture and N.

- **Suitable agro-ecology and growth requirement**: Best-adapted to high-rainfall areas.
  - Altitude range: Sea level to 2,000 m.a.s.l.
  - Climatic requirement: Rainfall 1,480–1,620 mm/y; optimum temperature 25–40^{o}C; resists drought if successfully established. Susceptible to frost.
  - Soil requirement: Prefers deep, friable fertile soils.
- ***Cultivation:*** Full land preparation.
  - Propagation: Usually by stem cuttings buried in 15 cm furrows, 2 nodes in soil and one exposed. One ha of grass provides planting material for 15–20 ha.
  - Fertilizer requirement: Responds well to fertilizers applied after every cut.
  - Companion species: *C. pubescens, N. wightii, P. phaseoloides.*
- Highest DM yield recorded is 84.8 t/ha when it was fertilized with 987 kg N/ha/yr and cut every 90 days under rain-fed conditions (2,000 mm/yr) (Puerto Rico). In Hawaii, it produced 336 t green forage/ha/yr.
- ***Utilization:*** Commonly used in a cut-and-carry system; also made into silage. For grazing, it should be heavily stocked to maintain it in a lush vegetative form; best grazed when the new growth consists of 5 new leaves. Slash coarse leafless stems. Makes good hay if cut when young; usually made into silage of high quality without additives.

5.8. Fodder beet (*Beta vulgaris*)

Fodder beet is an intensive fodder crop usually grown by commercial dairy farms (Figure 18).

- **Cultivation:** It is planted preferably on fertile plots near animal corrals where manure is deposited. It requires light soil with ample moisture. It is established from seed sown on

ridges, spaced 40 by 75 cm, alternate tubers in the row thinned after half the growing season for early use, the remaining allowed to grow until used.

- **Suitable agro-ecology and growth requirement**: Adapted to wide range of altitude, mean annual rainfall above 800 mm, long growing season of four months or more, if not, supplemental irrigation would be required for better yield.

- **Fertilizer requirement:** Generous application of farmyard manure up to 20 t/ha.

- **Expected yield:** Depends on length of growing period; being a biennial its tuber size increases with age as long as there is ample moisture. A single tuber can attain up to 37 kg fresh weight after some five months growth under irrigation (Debre Zeit, EIAR) (Figure 19). While under rain-fed conditions and soils with moderate fertility 100 t/ha fresh tuber fodder (14 t/ha dry matter) can be obtained.

- **Usage:** Mature tubers should stay in the ground until use. Every day, required quantity of fresh tuber is pulled out, chopped and fed to dairy cattle as supplementary feed preferably at milking time.

- **Selected varieties/cultivars:** CV Rosa Mammoth

- **Seed source**: Commercial cultivars available. Various seed companies in Italy, Spain, Portugal, France and UK can be contacted. Locally, limited quantity of foundation seed could be found from DZARC.

Figure 18. Fodder beet (*Beta vulgaris*) grown under rain-fed conditions at Debre Zeit Research Center.

Figure 19. Fodder beet (*Beta vulgaris*) grown under rain-fed supplemented with irrigation at Debre Zeit Research Center.

6. Summary

In the face of the highly increasing demand for arable land in the highlands, allocation of cultivable land for pasture crops seems unlikely now or in the near future. Therefore, production of conventional pastures at the levels of the subsistence farming community is a remote goal to achieve. An alternative approach would be introducing intensive fodder crops that could be grown

around farmers' homestead in backyard or fodder bank systems, both of which are essentially aimed at banking highly nutritious fodder materials for strategic feeding in dry seasons as supplement to fibrous feedstuff. There are highly promising fodder crops that have proved valuable under intensive systems preferably with some supplementary irrigation such as the small scale earthen ponds. These improved fodder crops and their management and utilization need to be demonstrated to the smallholder. The object of this technical manual is to provide such kind of basic information to the KDAs.